Robotic cleanliness in the TNO Reticle Handling Test Platform

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Introduction

Although developments on EUV pellicles look promising[1], particle contamination is still a major concern. Literature[2,3] shows that industry needs Particle-per-Reticle-Pass (PRP) levels in a range of 0.001[4] and 0.0001[3]. Therefore, TNO initiated a development program on ultra clean handling technology, using the TNO Reticle Handling Test Platform[5].

The TNO Reticle Handling Test Platform (RH-TP) focuses on ambient reticle handling. Control of particle generation and transport are the key elements in the reticle handling design. The robot has been shown to be the most important particle source of the system. In order to set a baseline for improvement, particle release from the robot was determined.

Test set-up

The handling robot consists of a scalar robot, which is placed on a linear track (see Figure 1).

Sample locations were selected close to possible particle sources (see Figure 2):

- Robot joints,
- Central column,
- Gripper,
- Linear track,
- Ventilator,
- Reference locations far away from moving elements

Airborne particle release

- New standard ISO 14644-14[6].
- With and without continuous movement of the robot part.
- Air is sampled 100 times for 1 minute with an APC (Lighthouse Solair 1100LD).
- Locations see Figure 2, red circles.

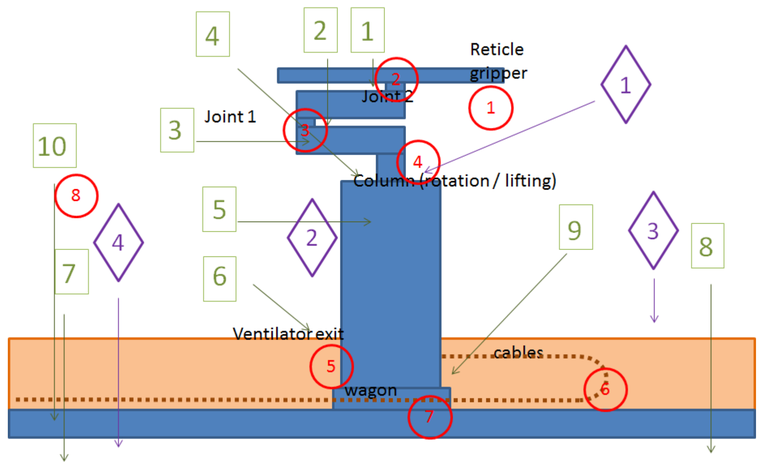

Figure 2: Schematic view of robot and sampling locations (①airborne particles, ◊witness wafers, 1 PMC measurements).

Deposition on robot surfaces & witness wafers

- Sampling surfaces were cleaned with IPA wipes (Figure 2, green squares) and witness wafers were installed (Figure 2, purple diamonds).
- A substrate was loaded / unloaded during 65,5 hrs.
- Witness wafers were removed and the cleaned surfaces were sampled using a Particle Measurement Card (PMC).
- Dark field microscopy was used to determine the number of added particles on the witness wafers (TNO RapidNano3: d > 50 nm on 36 cm^2) and PMC's (PartSens: d> 5 µm on 32 mm^2).

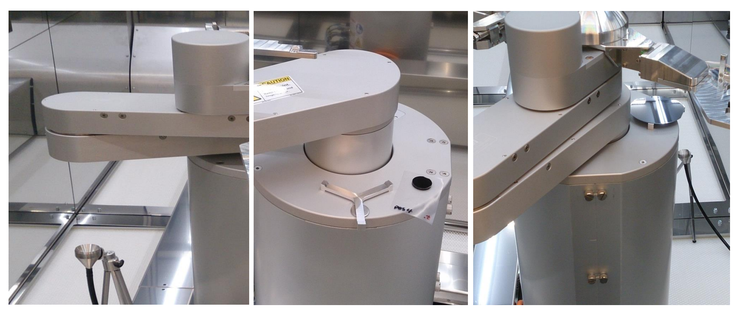

Figure 3: Sampling with APC (left), PMC (centre) and witness wafer (right)

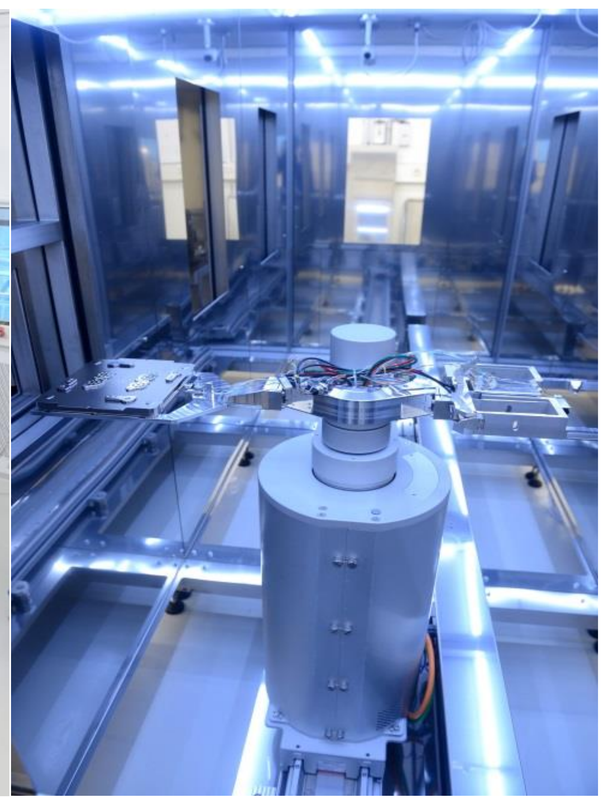

Figure 1: Reticle handler exterior (left), interior (right)

Results

Table 1 gives the upper concentration limit of observed airborne particles (> 0.1 µm) at different locations.

Particles were observed near the ventilator and the linear track. Locations near the reticle were free from airborne particles. This shows that the isolation strategy in the design[5] was implemented successfully.

Table 1: Upper Concentration Limit[6] for airborne particles at 0,1 µm

location	Upper concentration limit (particles /m3)		cleanroom class
	no robot movement	robot movement	
1	1	1	ISO 1
2		1	ISO 1
3	1	1	ISO 1
4		2	ISO 1
5		13225	ISO 6
6	1	2	ISO 1
7		35	ISO 2
8	1		ISO 1

Table 2 shows the number of added particles on several surfaces, sampled by PMC after 65,5 hrs operation. Many particles were found nearby the ventilator exit and on top of the robot shaft.

Table 2: Added particles (>5 µm) on robot surfaces sampled by PMC

location	added particles /cm2	location	added particles /cm2
1	1281	6	447
2	594	7	222
3	888	8	456
4	6741	9	14150
5	53	10	241

Table 3 shows the number of added particle on witness wafers. The large number of particles on locations 2 and 4 may be attributed to the ventilator drawing particles from robot joints.

Table 3: Added particles (>50 nm) on witness wafers

Location	added particles	Location	added particles
1	37	3	19
2	155	4	126

The general observation is that a low number of airborne particles was found around joints. Particles were found on robot surfaces, but not on a nearby witness wafer. This can be attributed to the distance between particle source and sampling point. Particles are not transported over large distances.

Conclusions

- Particles are released from robot joints and transported by the ventilator. Improvement is needed.
- Particle transport and deposition are local phenomena.
- The isolation strategy in design works well.

Literature

1. C. Zoldesi et al., "Progress on EUV pellicle development", Proc. of SPIE Vol. 9048 90481N-1
2. M. Amemiya, K. Ota, T. Taguchi, T. Kamono, Y. Usui, T. Takikawa and O. Suga, SPIE proc. 6921-142 (2008)
3. R. Peters, "ASML's NXE platform performance", EUVL Symposium 2013, Toyama (2013)
4. C. Lim, EUVL Symposium 2012, Brussels (2012)
5. W.E. Crowcombe, C.L. Hollemans, E.C. Fritz, J.C.J. van der Donck, N.B. Koster, "TNO Reticle Handling Test Platform", Proc. of SPIE Vol. 9048 904831-1
6. ISO/DIS 14644-14: Assessment of suitability for use of equipment by airborne particle concentration, 2014

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